GUIDANCE FOR DETERMINATION OF GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

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Guidance for Determination of Groundwater
Under the Direct Influence of Surface Water

This guidance supplements the Disinfection and Filtration Regulation (401 KAR 8:150) of the Kentucky Drinking Water Regulations and has been developed to assist public water supplies to evaluate their raw water sources as required by the Surface water Treatment Rule (SWTR). This rule requires the raw water sources for all public water supplies to be evaluated and classified as surface water, groundwater or groundwater under the direct influence of surface water. Should the source be determined to be influences by surface water, the requirements of the SWTR shall apply.

Obvious surface sources such as lakes, streams, springs, etc., are subject to the SWTR and no further evaluation is necessary. Raw water sources which are currently classified as groundwater, however, must be further evaluated to determine their ultimate classification. There are several methods which can be used to determine surface water influence. They include:

1. A determination that the local geology in conjunction with the well depth and design favors or precludes surface water influence.

2. Particulate analysis of the untreated water with regard to insects, algae, organic debris, or large diameter pathogens.

3. Long-term monitoring of the untreated water for variations in temperature, turbidity, conductivity, pH, and other parameters to determine any close correlation with nearby surface waters.

It shall be the responsibility of the water supply to employ individuals, firms, or organizations with adequate expertise to acquire the data necessary for the state evaluation. For community water supplies, this information must be submitted by June 29, 1994. Non-community supplies must submit the required data by June 29, 1999. A flow chart for this determination has been included as Appendix 1.

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[1]Adapted from "Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources," October 1990 Edition, U.S. EPA Office of Drinking Water, Washington, D.C.

Determination of the Direct Influence of
Surface Water on Groundwater Sources

While many raw water sources in Kentucky have historically been classified as groundwater, recent evidence suggests that a number of these sources may be under the direct influence of surface water and thus subject to the treatment requirements of the SWTR. One method of determination is an extensive evaluation of the raw water quality (particulate analysis-procedure 2-A). This method is rather labor intensive, however, and other criteria have been developed to help identify sources not subject to surface water influence. While not as definitive as quality analysis, they do provide a reasonable degree of accuracy. A summary of indicators has been included as Appendix 2.

All Kentucky raw water sources currently classified as groundwater must be evaluated by the following procedures:

<u>Procedure 1 – Review of the Source</u>

1.A. Water Pumped from Sand and Gravel Aquifers

If local geology and well construction verify that a source is producing coliform-free water from a properly constructed well at a production depth of greater than 50 feet from a sand and gravel aquifer, the source should not be subject to the SWTR. A minimum of three samples, collected over a three-month period, shall be analyzed for coliform bacteria to verify that the source is coliform free.

1.B. Other Sources

Groundwater sources meeting all of the following criteria will not be considered subject to the SWTR:

a. water is produced from a depth greater than 50 feet;

b. the well is properly located, constructed, and protected from surface contamination;

c. the casing and nearest collector lateral are located at least 200 feet from any surface water; and,

d. the water quality records indicate:

(1) No record of total or fecal coliform contamination in untreated samples collected quarterly over the past three years.

(2) No reports or history of turbidity problems associated with the source.

(3) No history of known or suspected disease outbreaks that could be associated with surface water.

1.C. On-Site Evaluation

An on-site inspection must be performed by competent personnel to evaluate the physical condition of the source. The inspection should include:

a. Physical condition of well seal, casing, etc.;

b. Evidence of surface water entering the source through defects; and,

c. Distance to obvious surface water.

If the evaluation indicates that the source is subject to direct surface water influence, the source must be reconstructed to correct the problem or be subject to the SWTR. Physical modifications to the well shall be in accordance with the Water Well Construction Practices and Standards Regulation (401 KAR 6:310) included as Appendix 3. Sources which do not meet the requirements of this procedure must be further evaluated in accordance with Procedure 2.

Procedure 2 - Particulate Analysis and Other Indicators

2.A. Particulate Analysis

Particulate analysis is intended to identify organisms which occur only in surface water as opposed to groundwater and whose presence in groundwater would clearly indicate that at least some surface water has been mixed with it. Specific identification of diatoms, rotifers, coccidia, insect parts, or Giardia cysts are considered as valid evidence of direct surface water influence. Other large-diameter (>7 um) organisms which are clearly of surface water origin, such as Diphilobothrium, should also, by their presence, be considered as indicators of surface-water influence.

Methods

Since standard methods have not been developed specifically for particulate analysis, there has not been consistency in the way samples have been collected and analyzed. Differences in the degree of training and experience of the microbiologists have added further to the difficulty in comparing results from sample to sample and system to system. The current limitations in sample collection and analytical procedures must be considered when interpreting the results. Until standardized methods are developed, the EPA Consensus Method (included as Appendix 4) is recommended as the analytical method for particulate analysis.

Sampling Method

Samples should be collected using the equipment outlined in the EPA Consensus Method. Samples should always be collected as close to the source as possible and prior to any treatment. If samples must be taken after disinfection, this should be noted on the sample and then analyzed as soon as possible. Samples must be collected during two periods when the source is most susceptible to surface water influence. Such critical periods will vary from source to source and will need to be determined on a case-by-case basis. For most systems, it may be one or more days following a significant rainfall (for example, two inches or more in 24 hours). In each case, particulate samples should be collected when the source in question is most affected. A surrogate measure such as source turbidity or depth to water table may be useful in making the decision to monitor. If there is any ambiguity in the particulate analysis results, additional samples should be collected when there is the greatest likelihood that the source will be affected by surface water.

Sample volume should be between 500 and 1000 gallons and should be collected over a four-to eight-hour time period. It is preferable to analyze a similar (± 10 percent) volume of water for all sources, preferably a large volume, although this may not always be possible due to elevated turbidity or sampling logistics. The volume filtered should be recorded for all samples.

Interpretation of Results

Identification of a Giardia cyst in any source water should be considered conclusive evidence of direct surface water influence. The repeated presence of diatoms in source water should also be considered as conclusive evidence of direct surface-water influence. However, it is important that this determination be based on live diatoms and not empty silica skeletons which may only indicate the historical presence of surface water.

Blue-green, green, or other chloroplast containing algae require sunlight for their metabolism as do diatoms. For that reason, their repeated presence in source water should also be considered as conclusive evidence of direct surface-water influence.

Rotifers, insects, and insect parts are indicators of surface water. Some rotifers do not require sunlight, and not all rotifers require a food source such as algae which originates in surface water. Their nutritional requirements may be satisfied by organic matter such as bacteria or decomposing soil organic material not necessarily associated with surface water. More precise identification of rotifers, i.e. to the species level, is necessary to determine the specific nutritional requirements of the rotifer(s) present. Further information on identifying rotifer species and on which species require food sources originating in surface water would be valuable, but is not readily available at this time. Without knowledge of which species is present, the finding of rotifers indicates that the source is either a) directly influenced by surface water, or b) it contains organic matter sufficient to support the growth of rotifers. It could be conservatively assumed based on this evidence alone that such a source is directly influenced by surface water. However, it is recommended that this determination be supported by other evidence, such as the source being near surface water, turbidity fluctuations being significant, etc.

Insects or insect parts likewise may originate in surface water, from the soil, or in the case of uncovered sources, they may have been airborne. If insects are observed in a particulate analysis sample, it should be confirmed, if possible, that there is no other route by which insects could enter the source other than surface water. Insects which spend a portion of their life cycle in water are the best indicators of direct surface water influence. Terrestrial insects should not be ruled out as surface water indicators, though, since their accidental presence in surface water is common.

Some researchers have indicated that some insects may burrow and that the finding of eggs or burrowing larvae may not be good indicators of direct surface-water influence. While this may be true for some insects, the distance burrowed in subsurface sediments is expected to be small and the larvae generally are large compared to Giardia cysts. Until further research suggests otherwise, it is recommended that the presence of insects or insect parts be considered strong evidence of surface-water influence. The strength of this evidence can be increased if the source in question is near a surface-water source and similar insects can be found in the surface-water. Coccidia are intracellular parasites which occur primarily in vertebrates and live in various tissues and organs including the intestinal tract.

Though not frequently identified by normal particulate analysis techniques, coccidia are good indicators of direct surface-water contamination. Cryptosporidium is commonly found in surface water, but due to its small size (4-6 um), it is not normally identified without specific antibody straining techniques.

Other microorganisms (>7 um) which are parasitic to animals and fish may be found and are good indicators of surface water influence. Examples include, but are not limited to, helminthes, ascaris, and Diphilobothrim.

2.B. Other Indicators

While particulate analysis is currently considered to provide the most direct evidence of surface water influence, a number of other indicators can be used to provide strong supportive evidence of such influence. These indicators include, among other items, turbidity, temperature, pH, hardness, and conductivity. A record of these parameters, measured daily from the groundwater source along with similar evaluation of nearby surface water and concurrent weather measurements, is necessary for a one-year period.

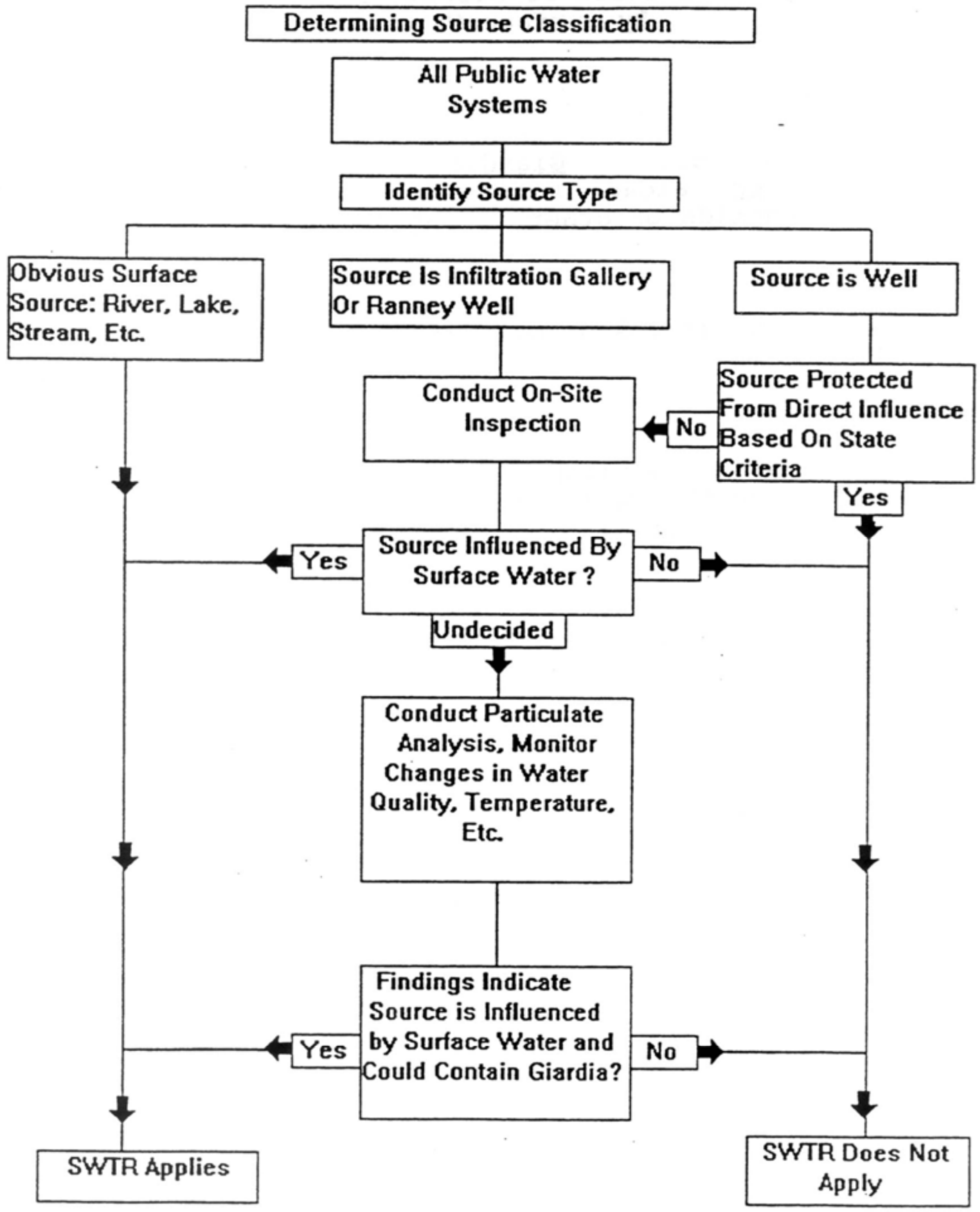
Turbidity variations of greater than 1.0 NTU over the period of one year may indicate surface water influence. Caution should be used in this evaluation, however, due to the fact that turbidity can be caused by very small particles (<1 um) not originating in surface water. In addition, larger particles may be filtered out and only the smallest particles migrate into the source. Only groundwater sources at risk to contamination from Giardia or other large pathogens (>7 um) are subject to the SWTR requirements.

Temperature fluctuations may also indicate surface-water influence. Fortunately, this information is easy to obtain, and if there is surface water within 500 feet of the source, measurements of both should be recorded for comparison. Changes in surface-water temperature closely followed by similar changes in ground source temperature would be indicative of surface water influence. Also, temperature changes (in degrees F) of greater than 15-20 percent over the course of a year appear to indicate source influence by surface water.

Changes in other chemical parameters, such as pH, hardness and conductivity, should be monitored for the source water and nearby surface water and results recorded. Again, these evaluations do not provide a direct indication that pathogens originating in surface water are present but can indicate whether the water chemistry changed in a pattern similar to surface water chemistry. At this time, no numerical guidelines are available to differentiate what is or is not similar, so these comparisons are more qualitative than quantitative.

Although classification deadlines of 1994 and 1999 have been set, it should be clear that the majority of the evaluations can not be made quickly. All public water supplies are strongly encouraged to begin their source evaluations as soon as possible so that compliance with the regulations can be maintained and any system modifications deemed necessary can be completed in a timely manner.

APPENDIX 1


Determining Source Classification
All Public Water Systems
Identify Source Type
Obvious Surface Source: River, Lake, Stream, Etc.
Source Is Infiltration Gallery Or Ranney Well
Source is Well
Conduct On-Site Inspection
No
Source Protected From Direct Influence Based On State Criteria
Yes
Yes
Source Influenced By Surface Water ?
No
Undecided
Conduct Particulate Analysis, Monitor Changes in Water Quality, Temperature, Etc.
Yes
Findings Indicate Source is Influenced by Surface Water and Could Contain Giardia?
No
SWTR Applies
SWTR Does Not Apply

APPENDIX 2

Summary of Indicators for Determination of Direct Influence By Surface Water

Biological

The presence of: Giardia lamblia, Diphilobothrim, Cryptosporidium, algae, rotifers, diatoms, insects, insect parts, chironomids or other living microorganisms.

Temperature

Temperature variations of over 15-20 percent over the course of a year.

Chemical Parameters

Variations in pH, conductivity, hardness or other chemical parameters over the course of a year that can be correlated with weather conditions or nearby surface waters.

Turbidity

Raw water turbidity in excess of 5.0 NTU or fluctuations of more than 1.0 NTU over the course of a year.

Other indicators of direct surface water influence are:

1. wells producing water from a depth of less than 50 feet;
2. wells utilizing an unconfined aquifer located within 500 feet of a body of surface water where the static level of water in the well is less than or equal to the level of water in the surface body;
3. wells with casings cut off near or below ground level;
4. wells improperly cased and back filled;
5. wells located in karst areas;
6. wells without sanitary seals;
7. customer complaints regarding water quality or water-related illnesses;
8. wells that become milky after a rain; and
9. wells with yields that rise rapidly after rains.

APPENDIX 3

NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
Department for Environmental Protection
Division of Water

401 KAR 6:310. Water well construction practices and standards.
RELATES TO: KRS 223.400 through 223.460, 223.991
STATUTORY AUTHORITY: KRS 223.420, 223.435, 224.70-100
NECESSITY, FUNCTION, AND CONFORMITY: This administrative regulation provides standards and requirements for the commercial practice of water well drilling. These requirements are necessary to ensure that the completed well provides an appropriate quality of product to the consumer while protecting the ground water resources of the Commonwealth. This administrative regulation fulfills the mandate of KRS 223.435 to promulgate administrative regulations establishing standards of practice for water well construction and of KRS 224.70-100 to protect water quality.
Section 1. Definitions. The terms used in 401 KAR 6:320 and this administrative regulation shall have the meanings given in KRS 223.400, 224.005, or in this section:
(1) "Abandoned" means a well unsuitable for its intended use that has been sealed or plugged to prevent entry of surface water and to prevent mixing of water from different aquifers.
(2) "Annular space" means the opening between a well-bore or excavation and the well casing or between a casing pipe and a liner pipe.
(3) "Aquifer" means a water-bearing formation that transmits water in sufficient quantity to supply a well.
(4) "Bedrock" means any solid rock exposed at the surface of the earth or overlain by unconsolidated materials or soils.
(5) "Consolidated formation" means a geological formation which is bedrock.
(6) "Construction" means all acts necessary for obtaining ground water by wells, including drilling or excavation of the well and installation or modification of casing, but excluding the installation of permanent pumps and pumping equipment.
(7) "Driller" means water well driller as defined in KRS 223.400.
(8) "Established ground surface" means the elevation of the ground surface at the site of the well.
(9) "Finished ground surface" means the final or permanent elevation of the ground surface at the site of the well.
(10) "Impervious" means any material which will not permit the passage of water at a rate greater than 1×10^{-7} centimeters per second (cm/sec) (e.g., clay).
(11) "Modification" means any change, replacement, or other alteration of the water well. This includes, but is not limited to deepening of a well, replacing or repairing a casing, replacing or repairing a well screen, installing a pitless adapter and any other changes of a well structure. Bailing and pump replacement are not modifications.
(12) "Monitoring well" means a well constructed when the actual or intended use in whole or part is the removal of water for the purpose of sampling, measuring or test-pumping for scientific, engineering or regulatory purposes.
(13) "Pitless well adapter" means a device designed for attachment to one (1) or more openings through a well casing. It shall be constructed so as to prevent the entrance of contaminants into the well through the opening, protect the water supply lines and plumbing from freezing and provide access to water system parts within the well.
(14) "Pitless well unit" means an assembly which extends the upper end of the well casing to above the finished ground surface. It shall be constructed so as to prevent the entrance of contaminants into the well, conduct water from the well, protect the water lines from freezing, and shall provide full access to the well and to water system parts within the well.
(15) "Pumping water level" means the elevation of the water surface in a well when water is discharged during pumping.
(16) "Rig operator" means any individual under supervision of a driller for whom an application has been submitted and who has been given a rig operator card from the cabinet and who may from time to time be in charge of well construction in the driller's absence.

(17) "Rig operator card" means an identification card provided to a rig operator by the cabinet after a certified driller has submitted an application requesting a card for the rig operator.
(18) "Static water level" means the level at which water stands in a well when no water is being taken from the aquifer either by pumping or by free flow.
(19) "Unconsolidated formation" means a geological formation such as sand or gravel, which has a tendency to cave in under natural conditions.
(20) "Well unsuitable for its intended use" means a well:
(a) The use of which has been permanently discontinued;
(b) Which is in such a state of disrepair that it cannot be used to supply groundwater;
(c) Which presents a health hazard;
(d) From which groundwater for useful purposes is not obtainable; or
(e) Bore-holes which:
1. Are dry;
2. Have caved in; or
3. Are unsuitable for further development and well construction.
Section 2. Scope. This administrative regulation provides minimum standards for location, construction and modification of water wells. No water well shall be constructed or modified contrary to the provisions contained in this administrative regulation. Sections 3 through 12 of this administrative regulation apply to water wells except monitoring wells. Section 13 of this administrative regulation applies to monitoring wells. Wells used solely for the purpose of recovery of pollutants shall not be included in this administrative regulation.
Section 3. General Requirements. (1) Certified driller required. All water wells subject to this administrative regulation shall be constructed only by persons having a valid certificate issued in accordance with KRS 223.400 through 223.460 and 401 KAR 6:320, or by persons under the supervision of certificate holders and having a rig operator card.
(2) Reports. Within thirty (30) days after a water well has been constructed or modified, the driller shall submit a report of construction to the cabinet. The report shall be submitted on the form entitled Kentucky Water Well Record (DEP-4045).
(3) Variance.
(a) If conditions are believed to exist at a proposed installation site which preclude compliance with the requirements of this administrative regulation, the driller may request a variance by submitting to the cabinet a Kentucky Water Well Variance Request Form (DEP-6036) outlining a specific proposal to be used in lieu of compliance with this administrative regulation. The request shall include a thorough description of the site (lot size, the location of sewers, septic tanks, buildings, seepage fields, and other sources of contamination on the property and adjacent property with distances shown to the proposed well), the section number and brief summary of the provisions for which a variance is requested, and a complete justification as to why the variance is needed and how the alternate standard ensures the protection of the quality of the groundwater and the protection of public health and safety. The driller shall give special emphasis to ensuring the protection of the public's health and safety. The driller shall provide a description of site-specific geologic and soil conditions. The cabinet shall notify the applicant in writing within thirty (30) days of its decision either to grant or deny the variance based upon a determination by the cabinet that the proposed variance shall ensure the protection of the quality of the groundwater and protection of the public health and safety. The driller shall request a variance and shall obtain approval before well construction begins. In case of an emergency, where the delay incurred due to the above-described variance procedure would cause undue hardship or loss of life to the intended user, the driller may obtain an oral variance, provided the above-listed information is provided to the cabinet within fifteen (15) days of the date such oral variance is issued.
(b) After any variance is issued regarding the location of a well with respect to various contamination sources in Section 6 of this administrative regulation, the driller for which a variance has been issued shall take two (2) water samples from the well and have them analyzed for fecal coliform at a cabinet-approved laboratory. The cabinet may require analysis for other water quality parameters which may exist in conjunction with the source of potential pollution as necessary to protect the health or safety of potential users. At the time the variance is approved, the cabinet shall notify the driller as to what these parameters will be. One (1) sample shall be

taken within thirty (30) days and the second sample shall be taken within sixty (60) days, but not less than thirty (30) days, after completion of the well.

(c) Examples of location problems which could preclude compliance with this administrative regulation would be where the proposed location of a well is too close to septic tanks, buildings, sewer lines, or barnyards as indicated in Table A.

(d) Examples of public health and engineering principles that may be considered in issuing a variance are ground surface conditions, depth of the water table, the location of sources of pollutants, the vulnerability of the aquifer to bacteria and other pollutants, and the geologic conditions at the site.

(4) Water sampling. All water samples shall be delivered to the laboratory within six (6) hours of the time they are taken and shall be kept at four (4) degrees centigrade (or forty (40) degrees Fahrenheit) during that time, but shall not be frozen. Containers for the water samples shall be sterile glass or plastic. However, drillers may obtain approval from the cabinet to perform fecal coliform analyses (except those required for variance approval) if they can demonstrate to the cabinet that they are capable of providing an accurate analysis.

(5) Display of certificate number. Drillers shall have their certificate numbers permanently affixed and prominently displayed on all drilling equipment used at construction sites. The certificate number shall be inscribed in the following manner: KY.CERT. XXXX-XXXX (insert certificate number in place of the X's). Numbers shall be at least three (3) inches in height and of a color that is easily distinguishable from that of the equipment. This number shall be removed if equipment is scrapped, sold, or otherwise changes ownership or if the driller's certificate becomes invalid.

(6) The documents listed in paragraphs (a) and (b) of this subsection are adopted and filed herein by reference. Copies of these documents may be obtained from the Natural Resources and Environmental Protection Cabinet, Division of Water, 18 Reilly Road, Frankfort, Kentucky 40601, (502) 564-3410. The material is available for public inspection and copying during business hours of 8 a.m. to 4:30 p.m. at the Division of Water, Frankfort Office Park, 18 Reilly Road, Frankfort, Kentucky 40601, (502) 564-3410.

(a) Kentucky Water Well Record (DEP-4045) (September 15, 1987); and

(b) Kentucky Water Well Variance Request Form (DEP-6036) (January 1, 1991).

Section 4. Design Factors. The driller shall design each well to include the following:

(1) Natural protection. Location of the well shall include use of every natural protection available to promote sanitary conditions.

(2) Geological formations. The well construction shall be adapted to the local or site-specific geologic formations and ground water conditions.

(3) Undesirable geological formations. Water bearing formations shall be prevented from contributing to a well by installing casing or a liner and properly sealing when such formations contain undesirable water or when the primary purpose for the well is to withdraw water from a deeper formation.

(4) Capacity. The well shall be constructed with the capacity to produce as much quantity of the desired water as the aquifer or aquifers can safely furnish.

(5) Durability. Construction methods and materials shall provide a durable well capable of maintaining safe water and protecting the aquifer over its useful lifetime and until the well is properly abandoned.

(6) Pitless well adapters. No well casing shall be cut off or cut into below ground surface except by a driller to install a pitless well adapter or pitless well unit. The well casing shall extend at least four (4) inches above established ground surface. If practicable, the well casing shall extend above any known conditions of flooding or run-off from the surrounding land after installation of a pitless well adapter or pitless well unit. Construction or installation of pitless well adapters or pitless well units shall be done in such a manner to provide a leak-proof seal.

Section 5. Location. (1) General. In establishing the location of a well, the driller shall consider sources of pollutants which exist on or adjacent to the premises where the well is to be located. As far as possible, the well shall be located on ground which is higher than sources of pollutants and shall have ready access for repairs, maintenance, treatment and inspection.

(2) Relation to sources of pollutants. In establishing minimum lateral distances to locate a well from potential sources of pollutants, the driller shall consider the character and location of the

sources of pollutants, types of geologic formations present, depth to the aquifer, direction of ground water flow, effect on the ground water movement by well pumping and possibilities of flooding of the site by surface waters. Sources of pollutants such as streams, refuse disposal sites, excavations, waste treatment facilities, buried oil and gasoline storage tanks, improperly constructed wells and cisterns shall be evaluated and a distance determined based on the pertinent facts.

(a) The minimum lateral distances shown in Table A shall apply for the sources of pollutants listed.

(b) When the upper formations are composed of materials with a permeability of 1×10^3 centimeters per second or greater, the lateral distances in Table A shall be doubled.

(3) Flood water. The construction of wells in locations subject to flooding shall be avoided. If no reasonable alternate site exists, wells may be constructed in flood zones only if water-tight construction is provided. If practicable, the casing of the well shall terminate not less than two (2) feet above the maximum known flood elevation.

(4) Relation to building. With respect to buildings, pits, and basements, the location of a well shall be as follows:

(a) Adjacent to building. When a well must be located adjacent to a building, it shall be so located that the center line of the well extended vertically will clear any projection from the building by not less than five (5) feet.

(b) Pits and basements. New wells shall not be constructed in pits or basements.

Section 6. Drilled Wells in Unconsolidated Formations. (1) General. In wells constructed in unconsolidated formations which extend the full depth of the well, including the screened area, the driller shall install a permanent casing, governed by the pumping level in the finished well. For pumping levels greater than twenty (20) feet below the ground surface, the driller shall install casing that extends five (5) feet below the pumping level. For pumping levels twenty (20) feet or less below the ground surface, the driller shall install casing that extends ten (10) feet below the pumping level. Under no conditions shall a driller install less than twenty (20) feet of permanent casing, excluding the screened interval. The driller shall fill the annular space between the casing and the drill hole. This may be accomplished by constructing an upper drill hole having a diameter four (4) inches greater than the inner diameter of the casing to be installed and extending to a depth of at least twenty (20) feet. The driller shall seal the upper drill hole with impervious drill cuttings, native clay, bentonite, or a neat cement-bentonite slurry after the casing is in place. Cable-tool drilling may accomplish proper seal through dry bentonite application while driving casing.

(2) Gravel pack construction. When an oversized drill hole (i.e., more than four (4) inches greater than the inside diameter of the casing) is constructed to permit the placement of a gravel pack around the well screen, the driller shall seal the annular space between the casing and drill hole in the top twenty (20) feet or twenty (20) feet below the point of pitless adapter attachment with impervious drill cuttings, native clay, a neat cement-bentonite slurry or bentonite. If a permanent outer casing is installed, the driller shall extend the outer casing to a depth of at least twenty (20) feet and, depending on the formations present, seal the annular space between the drill hole and the outer casing with impervious drill cuttings, native clay, bentonite, or a neat cement-bentonite slurry. The driller shall seal the annular space between inner and outer casings to prevent the entrance of pollutants from the surface.

(a) All gravel placed in the well shall be clean, washed and disinfected prior to placement or provisions made for disinfection in place.

(b) Gravel refill pipes may be installed if they terminate above established ground surface and are provided with watertight caps.

(c) In wells designed for placement of an artificial gravel pack, the driller shall provide an adequate screen having openings sized on the basis of the grain size of the gravel. The driller shall develop the well to ensure free entry of water without sediment.

(d) Under no circumstances shall the gravel pack extend to any closer than twenty (20) feet of the established ground surface.

Section 7. Drilled Well Construction in Consolidated Formations. (1) Where the soil overburden is thirty (30) feet or less in thickness, the driller shall drive or otherwise provide a watertight seal to a depth of at least twenty (20) feet below ground level and at least ten (10) feet into bedrock. The diameter of the drill hole shall be a minimum of one and three-quarter (1 3/4) inches greater than the inner diameter of the casing. The driller shall fill the annular space with a neat cement-bentonite slurry, bentonite, native clay, impervious drill cuttings, or a mechanical packer in combination with one (1) or more of the above materials. The driller shall install plastic casing as required in subsection (7) of this section.

(2) Where the soil overburden is greater than thirty (30) feet in thickness, the driller shall install the casing to a watertight seal, a minimum of two (2) feet into stable rock. When the casing is driven, the driller shall fit the casing with a drive shoe and drive the casing to a watertight seal. The driller shall seal the annular space around the casing with impervious drill cuttings, native clay, bentonite, a neat cement-bentonite slurry or a mechanical packer in combination with one (1) or more of the above materials. The driller shall install plastic casing as required in subsection (7) of this section.

(3) Where the well is drilled to obtain water from the bedrock, beneath a thick (greater than thirty (30) feet) overburden of soil or unconsolidated formations which are unstable and will settle back around the casing, the driller shall drive the well casing to a watertight seal. In instances where a temporary surface casing must be installed to stabilize the bore-hole and in order to facilitate drilling and permanent casing installation, the driller shall fill the annular space around the well casing with impervious drill cuttings, bentonite, a neat cement-bentonite slurry or native clay to a depth of at least twenty (20) feet. The driller shall not install plastic casing under these conditions.

(4) Where the well is drilled to obtain water from a lower formation the driller shall extend the casing at least two (2) feet below any creviced formation or fractured formation encountered and drive or install the casing watertight into stable bedrock. The diameter of the drill hole through the creviced formation shall be a minimum of one and three-quarter (1 3/4) inches greater than the inner diameter of the casing. The driller shall seal the annular space with a neat cement-bentonite slurry, bentonite, native clay, impervious drill cuttings, or a mechanical packer in combination with one (1) or more of the above materials. Where an outer casing is left in place, the driller shall seal the annular space between the casings with impervious drill cuttings, native clay, bentonite, a neat cement-bentonite slurry, or a mechanical packer in combination with one (1) or more of the above materials. In instances where voids are encountered, the driller shall extend the casing a minimum of two (2) feet into stable rock below the lowermost void and shall seal the annular space with impervious drill cuttings, bentonite, a neat cement-bentonite slurry, clay or a mechanical packer in combination with one (1) or more of the above materials.

(5) Flowing artesian well. All flowing artesian wells shall be shut in. The driller shall install casing to eliminate flow in the annular space and shall seal the annular space between drill hole and casing with a neat cement-bentonite slurry, bentonite, native clay, impervious drill cuttings, or a mechanical packer in combination with one (1) or more of the above materials.

(6) In all wells where the casing is driven, the driller shall not use plastic casing.

(7) Plastic casing installations. When plastic well casing is installed, the drill hole shall be a minimum of two (2) inches greater than the inner diameter of the casing. The driller shall clean the pipe spigot and socket and treat it with a cleaner-primer. The driller shall solvent cement the joints with a quick-setting cement, or thread and couple the joints. Other types of joints may be evaluated and approved by the cabinet. The driller shall cement a coupling on the bottom of the casing to stabilize it in the hole or use centralizers. The driller may use a steel nipple five (5) to ten (10) feet long on the bottom of the casing in lieu of the coupling when the well will be continued by drilling out through the bottom of the casing. In wells completed in consolidated formations, the driller shall set the casing into bedrock a minimum of ten (10) feet where the overburden is thirty (30) feet or less in thickness and a minimum of two (2) feet where the overburden is greater than thirty (30) feet in thickness to prevent leaking around the end of the casing. In wells in bedrock where the well will be drilled to total depth before casing is installed, the driller shall install a watertight mechanical packer at the bottom of the lowermost string of casing. The driller shall seal the annular space between the casing and wall of the drill hole with at least five (5) feet of bentonite immediately above the packer. The driller shall fill the annular space above the bentonite seal with impervious drill cuttings, native clay, bentonite, or a neat cement-bentonite slurry.

(8) In areas where the overburden is at least fifteen (15) feet thick and water can only be obtained at or just above the rock surface, the driller shall set the casing at or just above the rock. Under

these conditions, the driller shall seal the lowermost part of the annular space between the casing and wall of the drill hole with a minimum of two (2) feet of bentonite. The driller shall fill the remaining annular space above the bottom seal to the surface with a neat cement-bentonite slurry, bentonite or impervious clay. There shall be no less than twelve (12) feet of overburden from the ground surface to the bottom of the seal. If the casing is to be slotted or a screen installed, the driller shall not extend the slotted section above the bottom of the bentonite or cement seal. If water is encountered in drilling into the rock to develop a reservoir, the driller shall choose which water source is to be used and seal off all others.

Section 8. Special Type Wells. (1) General. Wells in this classification are dug, bored, driven, and radial collector. The choice of any one (1) of these as opposed to a drilled well is largely dictated by the characteristics of the water-bearing formations or aquifers in the local areas.

(2) Bored or dug well - well not finished with buried slab. Bored or dug wells that are not finished as buried slab wells shall comply with the following:

(a) Annular space. The driller shall grout the open space between the excavation and the installed casing with concrete. The driller shall pour the concrete a minimum of six (6) inches thick and without construction joints from the ground surface to a minimum of ten (10) feet below ground level. The driller shall be responsible for the installation of the concrete grout. The driller shall insure that the diameter of the well bore below the grouting is a minimum of four (4) inches greater than the outside diameter of the well casing and is filled with a gravel pack from the well bottom to the water-producing formation and with impervious material from the top of the gravel pack to the bottom of the concrete grout. The driller shall not extend the gravel pack any closer than ten (10) feet of the ground surface.

(b) Upper terminal. The driller shall extend the casing at least eight (8) inches above finished ground surface. The driller shall provide a cover slab at least four (4) inches thick, adequately reinforced and having a diameter sufficient to extend to the outer edge of the casing. The slab shall be constructed without joints. The driller shall slope the top of the slab to drain to all sides and shall provide a watertight joint where the slab rests on the well casing. If a manhole is installed, the driller shall insure that the manhole consists of a curb cast in the slab extending four (4) inches above the slab. The driller shall provide a watertight cover having sides which overhang the curb at least two (2) inches for any manhole.

1. If installing a vent, the driller shall provide a vent that consists of pipe extending above the slab with the open end turned down and not less than six (6) inches above the slab. The driller shall cover the open end with twenty-four (24) mesh or finer screen of durable material.

2. The driller shall cast in place adequate sized pipe sleeve or sleeves in the slab to accommodate the type of pump or pump piping proposed for the well.

(3) Bored or dug well - buried slab construction. The driller shall terminate the well casing at a depth of ten (10) feet or more below the ground surface. The driller shall use well casing meeting the requirements in Section 9 of this administrative regulation. The driller shall firmly imbed or connect the casing to a pipe cast in a reinforced buried concrete slab. The casing shall be a minimum of four (4) inches in diameter and extend from the concrete slab to at least eight (8) inches above finished ground surface. The driller shall fill the annular space between the casing pipe and the well bore with clean impervious material thoroughly tamped to minimize settling. The driller shall make the diameter of the well bore below the buried slab a minimum of four (4) inches greater than the outer diameter of the well casing. The driller shall fill the well bore with a gravel pack from the well bottom to the water table and with impervious material from the top of the gravel pack to the bottom of the concrete slab. The driller shall not extend the gravel pack any closer than ten (10) feet of the ground surface.

(4) Driven well. The well point, drive pipe and joints shall be structurally suitable to prevent rupture or distortion during the driving of the well. The driller shall construct the top ten (10) feet of the hole to a diameter of at least two (2) inches greater than the inner diameter of the drive pipe. The driller shall fill the annular space around the drive pipe with impervious material. The type of pump proposed for the well will determine how the top ten (10) feet or more of the well shall be completed. If the working barrel of a hand pump is to be located below ground surface, the driller shall enclose the upper portion of the well in steel or iron casing pipe to a point below the barrel. So called "frost pits" curbed with stone, brick, tile, or other materials shall not be installed.

(5) Radial collector well. Approval of plans for the well shall be obtained from the cabinet before construction. Factors that shall be considered for approval of a radial collector well include depth of well, types of soil formations, location of well and sources of potential contamination in the surrounding area.

Section 9. Construction Materials and Other Requirements. (1) Casing and liner pipe. In selection of casing and liner pipe, the driller shall consider the stress to which the pipe will be subjected during construction and the corrosiveness of the water with which it comes in contact. The driller shall install steel or plastic casing, except for bored or dug wells, which the driller shall construct in accordance with Section 8 of this administrative regulation and except for monitoring wells, which the driller shall construct in accordance with Section 13 of this administrative regulation. The driller shall install all pipe and casing in accordance with manufacturer's specifications. The driller shall not install used or rejected casing or pipe shall not be used.

(a) The driller shall install steel well casing that conforms to the minimum standards given in Table B; or

(b) The driller shall install plastic well casing and liners that meet the requirements given in Table C. Evidence of compliance shall be display of the National Sanitation Foundation seal on each section of casing.

(c) The driller shall install plastic well casing and liners that are Standard Dimension Ratio (SDR) rated, have an minimum impact classification of IC-1, and conform to the minimum requirements given in Table C.

(2) Outer casing. The driller shall install casing, intended for construction purposes only, that is of weight and design as necessary to be watertight and permit installation without distortion or rupture to the specified depth. The driller shall remove the outer casing upon completion of the well.

(3) Joints. The driller shall insure that all casing and liner pipe joints are watertight.

(4) Screens or perforated or slotted casing. The driller shall install screen or perforated or slotted casing openings that provide the maximum amount of open area consistent with strength of screen or casing and the grading of the water-bearing formation or gravel pack. The driller shall install materials with openings that permit maximum transmitting ability without clogging or jamming and are sized to provide sediment-free water to the well. Screens shall be made of noncorrosive material.

(5) Drive shoe. The driller shall equip the pipe that is to be driven with a drive shoe. The driller may use a collar or coupling for light driving. No driller shall drive plastic casing.

(6) Grouting guides. The driller shall provide a centering shoe for protective casing that is to be grouted in the drill hole or annular space. The driller shall provide sufficient guides or centralizers to permit the unobstructed flow and deposition of the thickness of grout specified.

(7) Cement grout. The driller shall use the procedures and materials for preparing and placing cement grout that follow:

(a) Concrete grout. The driller shall mix cement, sand, and water in the proportion of one (1) bag of cement (ninety-four (94) pounds) and an equal volume of dry sand to not more than six (6) gallons of clean water.

(b) Neat cement grout. The driller shall mix one (1) bag of cement (ninety-four (94) pounds) to not more than six (6) gallons of clean water.

(c) Neat cement-bentonite slurry. The driller shall mix one (1) bag of cement, (ninety-four (94) pounds) to seven and one-half (7 1/2) gallons of clean water and two (2) to six (6) percent bentonite (by weight two (2) to six (6) pounds) to increase fluidity and to control shrinkage.

(d) Application. The driller shall perform all cement grouting by adding the mixture from the bottom of the annular space upward in one (1) continuous operation until the annular space is filled or to the point of pitless adapter attachment. The driller may add bentonite, aquajel, or similar materials to the annular space in the manner indicated for grouting, prior to the cement grouting, to seal any small crevices or fissures and assure that the annular space is open.

(e) Setting time. The driller shall not resume drilling operations until the cement grout has set and hardened for at least forty-eight (48) hours when high-early-strength cement is used and at least seventy-two (72) hours when regular cement is used. The driller may reduce setting time from forty-eight (48) hours with high-early-strength cement and seventy-two (72) hours with regular

cement by addition of manufacturers' approved chemicals and following manufacturers' recommendations for setting time.
(8) Plumbness and alignment. The driller shall ensure that the bore of the hole is sufficiently plumb and straight to receive the casing without binding. The driller shall ensure that the casing is sufficiently plumb and straight that it will not interfere with installation and operation of the pump.
(9) Construction water. The driller shall obtain water used in the drilling process from a source which will not result in the introduction of pollutants into the well.
(10) For air rotary drilling, the driller shall inject water into the air stream at the rate of approximately three (3) gallons per minute.
(11) Drill cuttings. The driller shall use drill cuttings that are impervious to fill the annular space of a well to prevent surface water from percolating down the drill hole.
(12) The driller shall not use any material containing lead in constructing a water well.
Section 10. Finishing and Testing. (1) Upper terminal. The driller shall terminate the casing or riser pipe at a height above established ground surface consistent with proposed plans for a pump house and pump installation, but not less than four (4) inches above finished ground surface. If practicable, the driller shall not install casing less than two (2) feet above any known conditions of flooding by drainage or run-off from the surrounding land. The driller shall fit the well with a well cap or sanitary seal upon completion of the well and prior to departure from the well site. The driller shall compact and grade the ground surface surrounding the well to drain water away from the well.
(2) Disinfection. For all wells except monitoring wells, the well driller shall disinfect all wells upon completion of the driller's work. The driller shall introduce sufficient chlorine to give a concentration of at least 100 parts per million to the water in the well. (CAUTION: When working with chlorine, persons should be in ventilated place. The powder or strong liquid should not come in contact with skin or clothing. Solutions are best handled in wood, plastic or crockery containers because metals are corroded by strong chlorine solutions.)
(a) Drilled wells. The driller shall disinfect the well in accordance with the following:
1. Determine the amount of water in the well by multiplying the gallons per foot (from Table D) by the number of feet of water in the well.
2. For each 100 gallons of water in the well, use the amount of chlorine liquid or compound given in Table D. Mix this total amount in about ten (10) gallons of water. If dry granules or tablets are used, they may be added directly to drilled wells.
3. The total amount of this solution shall be poured into the top of the well before the seal is installed and splashed around the lining, or wall, of the well. Ensure that the solution has contacted all parts of the well.
4. Where the driller installs a pump, the driller shall connect one (1) or more hoses from faucets on the discharge side of the pressure tank to the top of the well casing and start the pump, recirculating the water back into the well for at least fifteen (15) minutes. Then open each faucet in the system until a chlorine smell is evident. Close all faucets. Seal the top of the well.
5. Let stand for several hours, preferably overnight.
6. After standing, operate the pump, discharging water from all outlets until all chlorine odor disappears. Faucets on fixtures discharging to septic tank systems shall be throttled to a low flow to avoid overloading the disposal system.
7. Where no pump is installed, the well shall be bailed until all chlorine odor disappears before sampling.
(b) Dug wells. The driller shall disinfect the well in accordance with the following:

Diameter of well (in feet)	3	4	5	6	7	8	10
Amount of 5.25% laundry bleach to use per foot of water (in cups)	1.5	3	4.5	6	9	12	18
Amount of 70% Hypochlorite granules to use per foot of water (in ounces)	1	2	3	4	6	8	12

1. The amount of disinfectant required is determined primarily by the amount of water in the well. Using Table E, calculate the amount of chlorine that must be added for each foot of water in the well, according to its diameter.
2. To determine the exact amount of bleach to use, multiply the amount of disinfectant indicated as determined by the well's diameter times the number of feet of water.
3. This total amount of bleach shall be added to approximately ten (10) gallons of water, and splashed around the lining, or wall of the well. Be certain that the solution has contacted all parts of the well, using the entire amount of disinfectant. Seal the top of the well.
4. When this is done, pump enough water so the strong chlorine odor is evident. When the odor is detected, stop the pumping and allow the solution to remain in the well overnight.
5. After standing, operate the pump, discharging water from all outlets until a colormetric test indicates the absence of chlorine. Faucets on fixtures discharging to septic tank systems shall be throttled to a low flow to avoid overloading the disposal system.

(c) Water samples. Upon completion and disinfection of a new well or modification of an existing well, the driller shall be responsible for having the well tested for fecal coliform if the well is for potable use. The driller shall also give the owner information prepared by the cabinet explaining the importance of water well sampling, procedures for sampling, and how the water can be tested to assure a safe supply of water. The water sample shall not be taken until all chlorine has been removed from the well.

Section 11. Modification of Wells. (1) General. Wells constructed prior to the effective date of this administrative regulation need not meet its provisions. However, when a well is modified, reconstructed, or repaired, the work shall include those changes necessary to make the well conform to this administrative regulation.

(2) Well pits.

(a) No new well pits shall be allowed.

(b) No person shall modify existing well pits. Any person modifying a well shall eliminate existing well pits. The driller shall extend the casing a minimum of four (4) inches above the finished ground surface. Any flooring and the walls of the pit shall be broken and removed and the pit shall be filled with compacted earth.

(3) Notification. Within thirty (30) days after modification of a well, the driller shall provide written notification of the modification to the cabinet. The notification shall be submitted on the form entitled Kentucky Water Well Record (DEP-4045), incorporated in Section 3(6) of this administrative regulation.

Section 12. Abandoned Wells. (1) General. If a constructed water well is not suitable for its intended purpose and is to be abandoned, or if a well is drilled too close to a previously constructed well the owner shall ensure that the abandonment procedures are implemented as soon as possible, but no later than thirty (30) calendar days after completion of the well or after the owner has made the decision that the uncompleted well or previously constructed well is not to be used. The driller shall ensure that the well is completely filled in such a manner that the vertical movement of water within the annular space is effectively and permanently prevented.

(a) Preparation for wells to be abandoned. Before a well which is to be abandoned is sealed, the driller shall measure the depth and check to ensure that there are no obstructions within the well which may interfere with plugging operations. The driller shall pull or drill out screens, casings and liner pipes whenever possible to assure placement of an effective seal. The driller shall remove at least the upper five (5) feet of casing, liner pipe, brick, stone, metal, or other materials in all wells to prevent the passage of water along the casing and entering the water-bearing strata. The driller shall pull rather than cut the top joint of all plastic or steel casing.

(b) Disinfection. The driller shall disinfect the well and fill materials by using sodium hypochlorite or calcium hypochlorite. The driller shall dissolve sufficient chlorine compound to produce a calculated concentration of at least 100 parts per million (100 ppm) available chlorine in double the volume of water in the well. The driller shall place the fill material in the well after the water in the well has been so treated. Cement grouts do not require disinfection.

(c) Fill materials. The driller shall fill the aquifer or water-bearing zones in the wells with clean (relatively free of organic matter), disinfected, and dimensionally stable materials. The driller shall mechanically pack the fill materials to avoid later settlement. Neat cement shall not require disinfection. Except as specified in paragraph (e) of this subsection and subsections (2) through (5) of this section, the driller shall use only neat cement grout, a neat cement-bentonite slurry, or bentonite in plugging water wells. In all cases, clay may be used to fill the uppermost five (5) feet of the bore-hole.

(d) Placement of grout. The driller shall introduce neat cement or neat cement-bentonite grout used as a sealing material in abandonment operations at the bottom of the well or interval to be sealed (or filled) and shall place it progressively upward to the top of the well. For all such sealing materials the driller shall use grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

(e) Permanent bridges. Permanent bridges may be used only where voids are encountered which are too large to be filled. Under these circumstances, the driller shall completely fill the well to the bottom of the void with impermeable material. The driller shall construct a permanent bridge immediately above the void. The permanent bridge shall be at least ten (10) feet thick. Permanent bridges shall be composed only of neat cement. The driller shall allow the cement to harden for at least twenty-four (24) hours, if Type I cement is used, or for at least twelve (12) hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials - except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable. Notification shall be given to the cabinet at least twenty-four (24) hours before a permanent bridge is to be installed.

(f) Preexisting contamination. A well unsuitable for its intended use which has been affected by salt water intrusion or any other pollutant shall be considered a special case. The method of filling and sealing such wells shall be submitted to the cabinet by the drillers and shall be subject to individual review and written approval by the cabinet prior to sealing. In the sealing of a double or multiple cased well, the driller shall submit a drawing of the well with a description of the proposed procedure and materials to be used, for prior approval by the cabinet.

(g) Well abandonment records. Before equipment is removed from the site, the exact location of the well or drill hole to be sealed and abandoned shall be determined and recorded, tying in the location with permanent reference points. The driller shall record all information relative to the abandonment procedures and the location of the abandoned well on forms provided by the cabinet with copies supplied to the cabinet and the owner of the land within thirty (30) days. The information shall be submitted on the form entitled Kentucky Water Well Record (DEP-4045) incorporated by reference in Section 6(3) of this administrative regulation.

(2) Abandonment of wells in unconsolidated formations. Drillers shall completely fill a well unsuitable for its intended use that is constructed only in unconsolidated formations and contains water under water table or atmospheric conditions. Clean, disinfected sand or gravel may be used as a fill material from the well bottom to the water table level. If the water-bearing formation consists of coarse sand or gravel and producing wells are located nearby, only sealing materials which do not adversely affect the producing wells shall be used. A driller shall not extend the sand or gravel fill any closer than ten (10) feet of the ground surface. The driller shall place a minimum of five (5) feet of neat cement grout, neat cement-bentonite slurry or bentonite above the sand or gravel fill. The driller shall fill the uppermost portion of the well above the cement or bentonite plug with clay or an impermeable material appropriate to the intended use of the land.

Neat cement, a neat cement bentonite slurry, or bentonite may be used to fill the well to the ground surface.

(3) Abandonment of wells in consolidated formations. The driller shall completely fill a well unsuitable for its intended use that is constructed in consolidated formations or bedrock with neat cement, a neat cement-bentonite slurry, or bentonite, if there is no artesian flow of water in the well. The driller shall not use sand or gravel except for those wells for which a well record is on file with the cabinet. Use of sand or gravel shall be considered a special case and the method of filling and sealing such wells shall be subject to written approval by the cabinet prior to sealing. Under these conditions, the cabinet may allow the use of sand and gravel to fill through the water-producing horizon, if there is limited vertical movement of water in the formation and such movement will not adversely affect the quality or quantity of water in producing wells. The driller shall place neat cement or neat cement-bentonite grout or bentonite immediately above the sand and gravel fill, extending up to within five (5) feet of the ground surface. The driller shall fill the uppermost five (5) feet of the bore-hole with clay or an impermeable material appropriate to the intended use of the land. In the event the casing cannot be pulled or drilled out, the driller shall use bentonite slurry to fill the length of the casing.

(4) Abandonment of flowing artesian wells. The sealing of abandoned flowing artesian wells or wells which are unsuitable for their intended use and in which there is vertical movement of water between aquifers requires special attention. The driller shall notify the cabinet at least twenty-four (24) hours before such a well is to be sealed. The driller shall pressure cement such wells with neat cement mixed with the minimum quantity of water that will permit handling. In order to place the cement, the driller shall restrict flow. Gravel or stone aggregate not more than one-third (1/3) of the diameter of the hole may be placed through the water-bearing horizon, if its extent is known. The driller shall place a well packer, cast-iron plug, or temporary bridge at the bottom of the confining formation immediately overlying the artesian water-bearing horizon to seal off the flow. Temporary bridges shall consist only of inorganic materials - except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction shall be acceptable. The driller shall place the neat cement grout in one (1) continuous operation from the top of the packer, plug or bridge to five (5) feet of the surface or to the bottom of an overlying water-bearing formation. In the latter situation it may be necessary to repeat the process described in this subsection. The driller shall fill the uppermost five (5) feet of the bore-hole with clay or an impermeable material appropriate to the intended use of the land.

Section 13. Monitoring Well Construction. (1) After July 1, 1991, no person shall construct or modify a monitoring well without having a valid certificate issued in accordance with KRS 223.400 through 223.460.

(2) Drillers shall construct monitoring wells to maintain existing natural protection against the introduction of pollutants into aquifers, prevent the entry of pollutants through the bore-hole, and prevent the intermingling of groundwater from different aquifers through the bore-hole. Compliance with this section shall not relieve the driller from specific requirements under other federal or state regulatory programs.

(3) The driller shall use materials in the construction of a monitoring well appropriate to the purpose of that well. The driller shall seal the annular space above the sampling depth with suitable material, such as cement grout or bentonite, in order to prevent the introduction of pollutants into the samples or the groundwater. The driller shall complete the well at least four (4) inches above ground level or shall install a waterproof flush mount device capable of preventing surface water run-off, pollutants and contaminants from entering the well. The driller shall label the well with a Kentucky well tag. Within thirty (30) days after a monitoring well has been constructed or modified, the driller shall provide the well with a locking well cap.

(4) The driller shall provide the cabinet with a record of the well as specified in KRS 223.440.

(5) The record shall be submitted on the form entitled Kentucky Monitoring Well Record (DEP-8043). The following document is adopted and filed herein by reference: Kentucky Monitoring Well Record (DEP-8043) (January 1, 1991). Copies of this document may be obtained from the Natural Resources and Environmental Protection Cabinet, Division of Water, 18 Reilly Road, Frankfort, Kentucky 40601, (502) 564-3410. The material is available for public inspection and copying during business hours of 8 a.m. to 4:30 p.m. at the Division of Water, Frankfort Office Park, 18 Reilly Road, Frankfort, Kentucky 40601.

(6) The owner shall ensure that monitoring wells are properly abandoned within thirty (30) days of the last sampling date or the determination is made that the monitoring well is unsuitable for use as a monitoring well.
(7) This section shall become effective on July 1, 1991.

TABLE A	
Required Minimum Distances From Lateral Sources of Pollutants	
Lateral Sources of Contamination	Minimum Distances for Clay & Loam Soils
Cess Pools	150 feet
Leaching Pit	100 feet
Pit Privy	75 feet
Subsurface Seepage Tile	75 feet
Lateral Fields	70 feet
Manure Piles	75 feet
Septic Tank	50 feet
Barnyard	50 feet
Sewers (noncast iron) (nonperforated)	50 feet
Sewers (cast-iron with watertight leaded or mechanical joints)	15 feet
Sewers (Schedule 40 or heavier plastic pipe with solvent cemented or elastomeric seal joints.) Pipe is solid pipe not perforated.	15 feet
Footing Drains (no connection to a sewer or a sump handling sewage)	10 feet
Pump House Floor Drain	2 feet
Cemeteries	75 feet
Property Lines	20 feet

TABLE B			
Casing and Liner Pipe Weights and Dimensions			
Size (inches)	External Diameter (inches)	Thickness (inches)	Weight (pounds per foot)
1	1.315	0.120	-
1 1/4	1.660	0.120	-
1 1/2	1.900	0.120	-
2	2.375	0.120	2.89
2 1/2	2.875	0.120	3.53
3	3.500	0.120	4.33
3 1/2	4.000	0.120	4.97
4	4.500	0.188	8.66
5	5.563	0.188	10.79
6	6.625	0.188	12.92
8	8.625	0.277	24.70
10	10.750	0.307	34.24
12	12.750	0.330	43.77
14	14.000	0.375	54.57
16	16.000	0.375	62.58
18	18.000	0.375	70.59
20	20.000	0.375	78.60

Pipe sizes not listed that are less than eight (8) inches in diameter shall match listed values as closely as possible.

Pipe sizes not listed that are eight (8) inches in diameter or greater shall be Schedule 30 pipe as a minimum.

TABLE C			
Plastic Casing and Liner Pipe Specifications			
Size (inches)	SDR	External Diameter (inches)	Minimum Wall (inches)
4	26	4.500	0.173
5	26	5.563	0.214
6	26	6.625	0.255
8	26	8.625	0.332
10	26	10.750	0.413
12	26	12.750	0.490
14	26	14.000	0.539
16	26	16.000	0.616

TABLE D		
Required Amounts of Disinfectant		
Disinfectant Diameter of Well in Inches	Volume of Water in Gallons Per Foot of Depth	Required for Each 100 Gallons of Water
3	0.37	Laundry Bleach (5.25% chlorine) = 3 cups
4	0.65	
5	1.0	Hypochlorite Granules (70% chlorine) = 2 oz.
6	1.5	
8	2.6	
10	4.1	
12	6.0	

1 cup = 8 ounces measuring cup
(2 cups = 1 pint; 4 cups = 1 quart)

1 ounce = 1 heaping tablespoon granules
(16 ounces = 1 pound)

TABLE E							
Required Amounts of Disinfectant							
	Diameter of well (in feet)						
	3	4	5	6	7	8	10
Amount of 5.25% laundry bleach to use per foot of water (in cups)	1.5	3	4.5	6	9	12	18
Amount of 70% hypochlorite granules to use per foot of water (in ounces)	1	2	3	4	6	8	12

(11 Ky.R. 1950; Am. 12 Ky.R. 144; eff. 8-13-85; 17 Ky.R. 2762; 3142; eff. 5-22-91.)

APPENDIX 4

EPA CONSENSUS METHOD FOR GIARDIA CYST ANALYSIS

TESTING FOR GIARDIA IN WATER

To begin the work groups on testing, Jay Vasconcelos gave a slide presentation about the testing method used in the Region 10 Laboratory. The following pages summarize his talk.

METHODS OF TESTING FOR GIARDIA IN WATER (George (Jay) Vasconcelos, (Regional Microbiologist, Region 10 Laboratory, Manchester, Washington)

Background:

Although recent development of an excystation technique by Drs. Bigham, Meyer, Rice and Schaefer could in the future lead to developing cultural methods, at this time no reliable methods exist for culturing Giardia cysts from water samples. At present, the only practical method for determining the presence of cysts in water is by direct microscopic examination of sample concentration.

Microscopic detection in water-sample concentrates isn't an ideal process. Finding and identifying the cysts relies almost entirely on the training, skill, experience and persistence of the examiner. (And it is a skill not widespread among water-supply laboratories.) But despite its limitations, microscopic identification is currently the best method we have.

Years ago, the basic assumption was made that in order to find Giardia cysts in water, some form of sample concentration was necessary. As early as 1956, labs were using membrane filters with a porosity of 0.45 um. With few exceptions, these attempts were unsuccessful. The Center for Disease Control has tried particulate filtration, with diatomaceous earth as the medium. This removed the cysts from the water, but the cysts couldn't be separated from the particles of diatomaceous earth.

With the recent increase in the incidence of water borne giardiasis, further efforts have been made to improve the detection method. An ideal method would be one that recovers all cysts in a water sample rapidly, cheaply and simply; allows rapid detection, identification and quantification; and provides information on the viability of and/or infectivity potential of cysts detected.

Unfortunately, no such method exists. The methods presently available can be broadly separated into two general stages: primary concentration and processing (see Table 1 on next page), and detection and identification (see Table 2 on next page).

Methods of Testing for Giardia in Water (Continued…)

Table 1: PRIMARY CONCENTRATION AND PROCESSING METHODS

METHOD	INVESTIGATOR(S)	RESULTS
1. Membrane Filtration		
Cellulosic (47mm-0.45 um)	Chang & Kabler USPHS, 1956	Generally unsuccessful
Polycarbinate (293mm-5 um)	Pyper, DuFrain & Henry Eng 1982, (unpublished)	Passing 1 gal/min @ 10 PSI. 15-1800 gal total
2. Particulate Filtration (diatomaceous earth, sand, etc.)	Shaw et al, 1977 Jurenek, 1979	Generally good removal but poor eluation
3. Algae (Foerst) Centrifuge	Holman et al, 1983 DHHS, Washington	Good rapid recovery, but limited in field use.
4. Anionic and Cationic Exchange Resins	Brewer, Wright State UN. (unpublished)	Generally unsuccessful
5. Epoxy-Fiberglass Balston Tube Filters (10”-8um)	Riggs, CDHS Lab, Berkley, CA (unpublished)	Overall recovery 20-80%
6. Microporous Yarnwoven Depth.Filters (7 & 1um orlon & polyprolylene)	Jakubowski, Erickson, 1980, EPA-Cincinnati	Recovery 3-15% Extraction ave. 58%
7. Pellican Cassette System	Millipore Corp. (unpublished)	May be useful for processing filter washings
8. Filterwashing Apparatus	DuWalle, U. of Wash., 1982 (unpublished)	Clains 75% recovery from orlon filters

Methods of Testing for Giardia in Water (Continued…)

Table 2: DETECTION METHODS

METHOD	INVESTIGATOR(S)	RESULTS
1. Immunofluorescen		
DFA	Riggs, CSDHS Lab, Berkley, CA 1983	Good prep., Cross Rx
IFA	Sauch, EPA-Cincinnati Riggs, CSDS	Still under study
Monoclonal Antibodies	Riggs, CSDHS Sauch, EPA-Cincinnati (unpublished)	Still under study
2. ELISA Method	Hungar, J. Hopkins MD, 1983	Feces samples only
3. Brightfield/Phase Contrast	EPA Consensus method	Ongoing

Methods of Testing for Giardia in Water (Continued…)

EPA Consensus Method:

In September, 1980, the EPA convened a workshop on Giardia methodology in Cincinnati. Its main purposes were to identify the best available methodology, and to agree on a reference method. The five labs in attendance recognized that any proposed method would be based in large part on opinions and personal preferences rather than on hard data, but that agreeing on a consensus method would promote uniformity and provide a basis for future comparisons. Our lab has modified the EPA consensus method slightly for our use. This method is shown below.

Filter unwound into quarters → Rinsed in distilled water with polysorbate 20→

Settled overnight, or centrifuged → Collect sediment and add 2% Formaldehyde in

PBS→ Settled overnight, or centrifuged → Collect sediment

If sediment is >1 g, then Sucrose or Percoll-sucrose Gradient.

If sediment is <1 g, then $ZnSO_4$ Flotation.

Afterwards, Microscopic observation of the entire Concentrate (Brightfield/Phase-contrast)

CONCENTRATING, PROCESSING,
DETECTING AND IDENTIFYING <u>GIARDIA</u> CYSTS IN WATER

The following pages contain background information supporting Jay Vasconcelos' talk, "Methods of Testing for Giardia in Water."

CONCENTRATING, PROCESSING,
DETECTING AND IDENTIFYING GIARDIA CYSTS IN WATER

TABLE 1: PRIMARY CONCENTRATION AND PROCESSING METHODS

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7. Pellican Cassette System	Millipore Corp.	May be useful for processing

	(unpublished)	filter washings
8. <u>Filterwashing Apparatus</u>	DuWalle, U. of W. 1982 (unpublished)	Claims 75 percent recovery from orlon filters

CONCENTRATING, PROCESSING, DETECTION AND IDENTIFYING GIARDIA CYSTS IN WATER

PRIMARY CONCENTRATION AND PROCESSING METHODS

1. MEMBRANCE FILTER (MF) METHODS

   A. Cellulosic (mixed esters of cellulose)

      1. Chang and Kabler in 1956
         First to use MF for cyst recovery. Recovered 20-42 percent at cyst concentration of 3, 5, and 10 cyst/gal.-no cyst found at 1 cyst/gal.

      2. Method was used in 1965 Colorado outbreak (Moore, et al, 1969) using 2 liter size water samples from 10 sites. No cysts were detected. Use of cellulosic filters have generally not been successful in demonstrating cysts in drinking water.

   B. Polycarbonate (PC) Filters

      1. Luchtel and Colleages in 1980 and used 293 mm, 5.0 um pore size nucleopore (PC) filters to concentrate formalin-fixed, G. lamblia cysts from 20 L tap water samples. Recovery rates of approximately 75 percent were reported.

      2. Pyper of DuFrain and Henry Engineers claim good recovery with same nucleopore filter at a flow rate of 1 gal./min., not over 10 PSI, passing 15-1800 gal. In just over 24 hours.

   C. Even with those claims by Pyper and Luchtel, the MF Method has only once (Aspen, 1965) been successful in demonstrating cysts in water—probably because:

      1. Inability to process a sufficient volume.

      2. Inability to remove cysts from filter.

      3. Cysts were not present at a time of sampling during or after outbreak.

2. PARTICULATE FILTRATION

a. SAND - CDC (Shaw, 1977) used high-vol filtration through swimming pool sand filter (280,000 gal. Total over 10 days) – was back flushed into 55 gal. Drums and coagulated w/alum. Concentration fed to beagle puppies and after treatment (cheesecloth to wire screening to 30 um MF to centrifuge) was examined microscopically. First time cysts observed in water supply after concentration.

b. Diatomaceous earth (DE) - CDC (Juranek, 1979) used DE to remove cysts from seeded water. Problem was that cysts could not be removed from DE particles. Brewer (1983) claims 5.2-31.1 percent recovery from DE backwash. Retention through 3 forms (celite 505, HyFlo-Supercel and celite 560) at cyst concentration ranging from 6-16,000 cyst/L. Recovery range between 66-100 percent.

3. ALGAE CENTRIFUGE

   a. Was found to recover more cysts (10X) than a series of MF-filters and nylon screens: 5 vs. 1 day by MF.

   b. May be impractical in field because of power requirement.

   c. If used in lab, 1 large single sample collected in the field could miss cyst.

   d. May find application for concentration cysts from orlon filter washings.

4. ANIONIC AND CATIONIC EXCHANGE RESINS (Brewer – unpublished)

   a. Based on hypothesis that cysts could be attracted to charged surfaces, cysts have a charge of approximately 25mV at pH 5.5 which increases in electro-negativity as the pH rises to 8.0.

   b. Charge attraction techniques have been used for concentration of both bacteria and viruses in water.

   c. Five exchange resins were tested:

      1.) 49 percent recovery from anionic Dowex 1-XY columns
      2.) 38 percent recovery from cationic Dowex 50W-X8 columns

   d. Compared to parallel tests w/diatomaceous earth, exchange resins less efficient in retention.

5. BALSTON EPOXY-FIBERGLASS TUBE FILTERS

a. Riggs of CSHD, Viral and Rick. Lab., can filter 500 gallons drinking water thru 10" – 8 um Balston tube filter.

b. Backflushes w/1 L 3 percent beef extract or solution of 0.5 percent potassium citrate.

CONCENTRATING, PROCESSING,
DETECTING AND IDENTIFYING GIARDIA CYSTS IN WATER

c. Concentration is centrifuged w/40 percent potassium citrate and middle layer filtered throught 5 u polycarbonate filters.

d. Uses direct immunofluorescence antibody technique for detection and identification.

e. Claims 20-80 percent efficiency in collection, preprocessing and ID.

6. MICROPOROUS YARNWOVEN DEPTH FILTERS

a. In 1976 EPA developed a concentration-extraction method involving large volumes of water through microporous yarnwoven orlon-fiber filters.

b. This method has been tentatively adopted as the "method of choice" for concentrating cysts from water supplies.

c. Since initial studies which showed only 3-15 percent recovery with a mean of 6.3 percent and a 58 percent extraction rate, several changes have been made which may have increased the retention rate to >20 percent.

    1. Gone from 7 to 1 um porosity filter;
    2. Limited the rate of flow to ½ gallon/min;
    3. Limited the pressure head to 10 PSI; and,
    4. Have gone to polypropylene filters in lieu or orlon

d. It was the first method successfully used to detect cysts in the distribution system of a community water supply.

e. Is the recommended filter to be used by the EPA consensus method.

7. PELLICAN CASSETTE SYSTEM

a. Is a plate and frame style holder which accepts both ultra thin and depth type filters.

b. Has from 0.5 to 25 ft^2 of filter area.

c. Has not been investigated thoroughly but has had some success in virus concentration.

d. Its main application for cyst recovery may lay with the processing of filter washings.

CONCENTRATING, PROCESSING, DETECTING AND IDENTIFYING GIARDIA CYSTS IN WATER

9. FILTERWASHING APPARATUS

   a. This is a proposed device by DuWalle, 1982 from University of Washington, for unwinding the fibers from the filter cartridge while repeatedly brushing and squeezing them while in a bath solution.

   b. Bath could contain either a surfactant or pH controlled solution.

   c. Potential claims are as high as 75 percent extraction of cysts from the fibers.

TABLE 2: DETECTION METHODS

1.	Immunofluorescence		
	a. DFA	Riggs, CSDHS Lab, Berkeley, CA 1983	Good prep., Cross Rx
	b. IFA	Sauch, EPA-Cincinnati Riggs, CSDS	Still under study
	c. Monoclonal Antibodies	Riggs, CSDHS Sauch, EPA-Cincinnati (unpublished)	Still under study
2.	ELISA Method	Hungar, J. Hopkins MD, 1983	Feces samples only
3.	Brightfield/Phase Contrast	EPA Consensus method	Ongoing

DETECTION METHODS

1.a. DIRECT FLUORESCENT ANTIBODY (DFA) TECHNIQUE

1. Riggs has produced a high titer purified immune sera to Giardia lamblia cysts in guinea pigs and labeled it with fluorecein isothio cyanate. Sera is purified through NH_4OH and DEAE sefadex fractionation.

2. Obtained cross reactions with Chilomastix mesnili cysts but claims it can be easily distinguished from Giardia by its smaller size.

CONCENTRATING, PROCESSING
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1.b. INDIRECT FLUORESCENT ANTIBODY (IFA) TECHNIQUE

1. Sauch using IFA with immune sera from rabbits (unpurified). It is reacted with commercially available fluorescent-labeled goat anti-rabbit gamma globulin.

1.c. MONOCLONAL ANTIBODIES

1. Using clones of hybridoma cell lines obtained by fusing mouse myeloma cells with spleen cells from mice (BALB/c) immunized with G. lamblia trophozoites.

2. Produced eight monoclonal antibodies evaluated by IFA against both trophs and cysts.

   a. 3/8 stained the ventral disk;
   b. 2 stained the nuclei;
   c. 2 stained cytoplasmic granules; and,
   d. 2 stained membrane components.

3. Variability in staining may be due to differences in stages of encystment.

4. Preliminary results indicate monoclonal Abs may give rapid and specific ID of cysts.

5. Rx may be too specific, not reacting with all human forms of G. lamblia may have to go to polyclonal Abs.

2. ELISA METHOD

   a. Hungar at John Hopkins (unpublished) has produced a detection method by ELISA using an intact "sandwich" technique in 96-well microtiter plates.

   b. Using antisera from 2 different animals (may present problem).

   c. Need a minimum of 12 cysts/well for color Rx.